



Foundation Initiative 2010

Establishing the Foundation for DoD Range Interoperability



Ms Rosemary Enright

FI 2010 Cadre

Northrop Grumman Information Technology

23 October 2002



Foundation Initiative 2010 (FI 2010)

- **FI 2010 Overview**
- **TENA Architecture**
- **TENA Implementation Strategy**
- **Where We Stand**

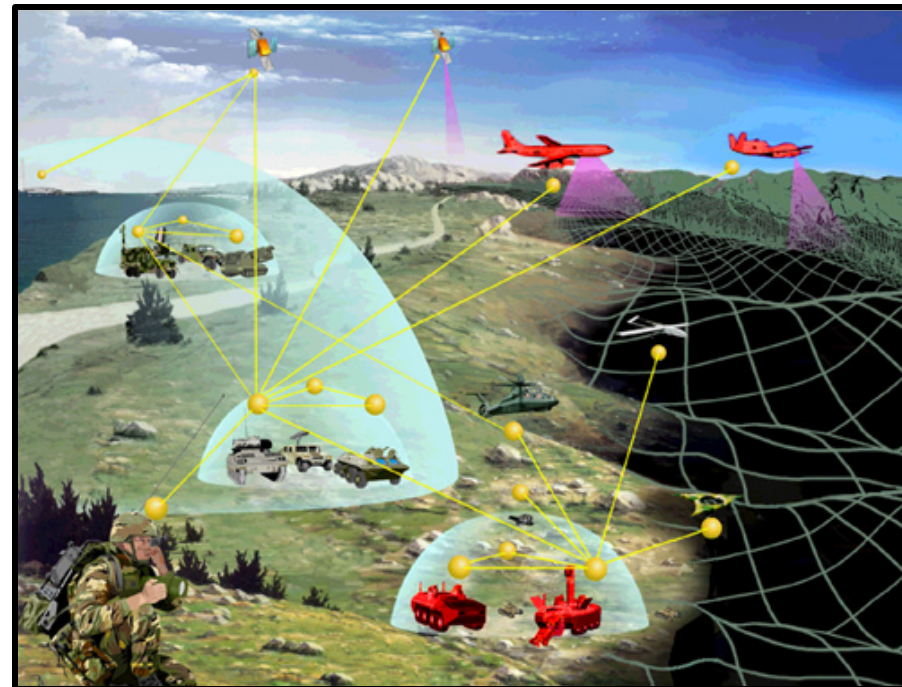


Foundation Initiative 2010

Overall Vision



- **Design and prototype a technological infrastructure to enable interoperability and reuse within the range community**
 - Seamless environments that integrate test ranges and facilities, training ranges, laboratories, and modeling and simulation (M&S) assets
 - Improve the scope and scale of testing and training the increasingly complex systems and missions in a cost-effective manner
- **Recognize that our solutions need to be more than quality software, we need to:**
 - Elegantly solve key usability issues
 - Satisfy the core operational and performance requirements
 - Work with the range community so the solutions are implemented
- **Lay the groundwork for full support for integrated multi-range events**





Driving Technical Requirements



- **Interoperability**

- The characteristic of a suite of independently-developed components, applications, or systems that implies that they can work together, as part of some business process, to achieve the goals defined by a user or users.

- **Reusability**

- The characteristic of a given component, application, or system that implies that it can be used in arrangements, configurations, or in system-of-systems beyond those for which it was originally designed.

- **Composability**

- The ability to rapidly assemble, initialize, test, and execute a system from members of a pool of reusable, interoperable elements.
- Composability can occur at any scale — reusable components can be combined to create an application, reusable applications can be combined to create a system, and reusable systems can be combined to create a system-of-systems.



Foundation Initiative 2010 (FI 2010) Update

- FI 2010 Overview
- **TENA Architecture**
- TENA Implementation Strategy
- Where We Stand



Achieving Interoperability, Reusability, and Composability



■ **Interoperability** requires:

- A common architecture —————→ **TENA**
- An ability to meaningfully communicate
 - A common language —————→ **TENA Object Model (OM)**
 - A common communication mechanism ———→ **TENA Middleware**
 - A physical connection between the two systems —————→ **Network, shared memory**
- A common context
 - A common understanding of the environment —————→ **TENA Object Model (Environment)**
 - A common understanding of time —————→ **TENA OM, TENA Middleware**
 - A common technical process —————→ **TENA Technical Process**

■ **Reusability** and **Composability** require the above, plus

- Well defined interfaces and functionality for the application to be reused —————→ **Reusable Tools, Repository**



Foundation Initiative 2010

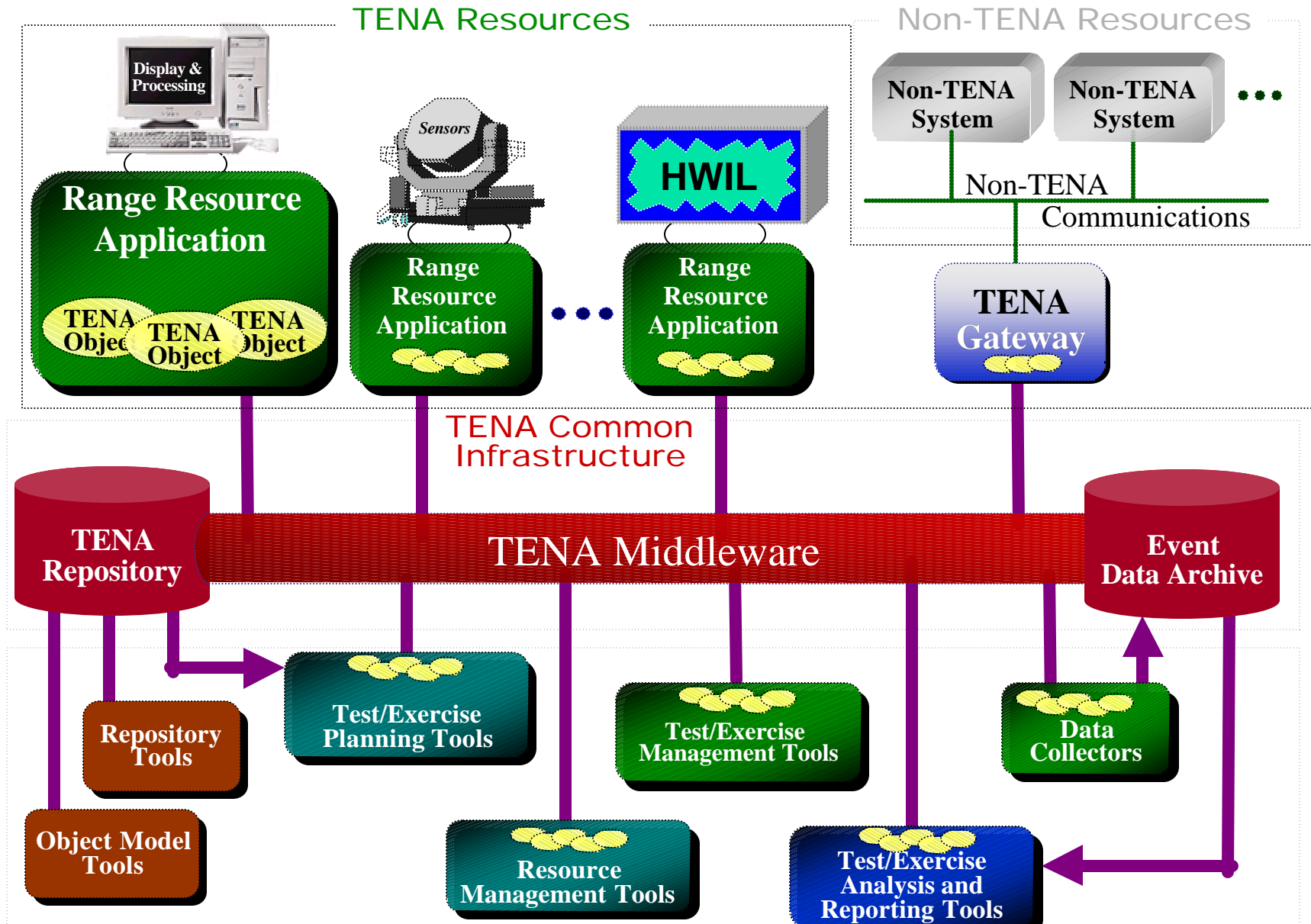
Project Objectives



- Define a common Architecture for the test/training range community – called “TENA” (Test & Training Enabling Architecture)
 - Define a common Object Model to be used across the ranges
 - Define and build a common Software Middleware that will:
 - Comply with the architecture
 - Use the object model
 - Build on the HLA
 - Enhance interoperability and reuse among the ranges
- Common understanding of range processes
 - the Logical Range ConOps
 - Provides a common understanding to range users how logical ranges are created (from the integration of range resources), what their capabilities are, and how they are utilized, operated, and controlled
- Define and prototype common Tools to configure and conduct multi-range, synthetic test events or training exercises
 - Create distributed, synthetic battlespaces with real weapon systems
 - Link multiple ranges together to form a larger, cohesive range
 - Enable testing, assessment, experimentation, and training of weapon system interoperability, C4ISR, and system-of-systems



TENA Architecture Overview





Ways TENA Can Exchange Data



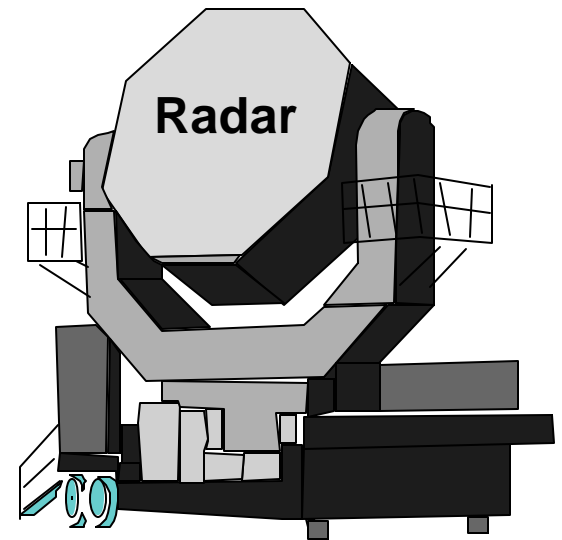
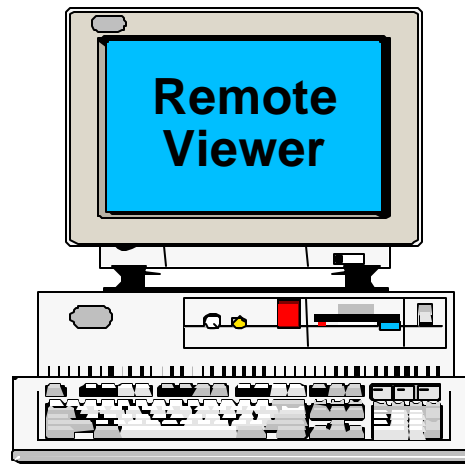
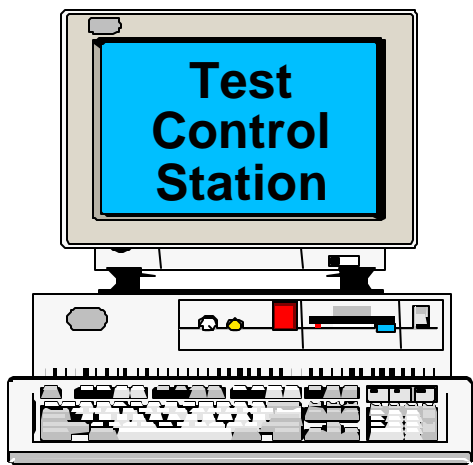
- **TENA presents to the range user a unification of several powerful inter-application communication paradigms**
 - **Publish/Subscribe**
 - Similar in effect to HLA, DIS, or other PDU-based communication systems
 - Each application publishes certain types of information (the publication state) which can be subscribed to by any other application
 - **Remote Method Invocation**
 - Similar to CORBA or Java RMI
 - Each object that is published may have methods that can be remotely invoked by other applications
 - **Messages**
 - Individual messages that can be sent from one application to one or more other applications
 - **Data Streams**
 - Native support for audio, video, and telemetry



Logical Range Simple Example



TENA specifies an architecture for range resources participating in **logical ranges**



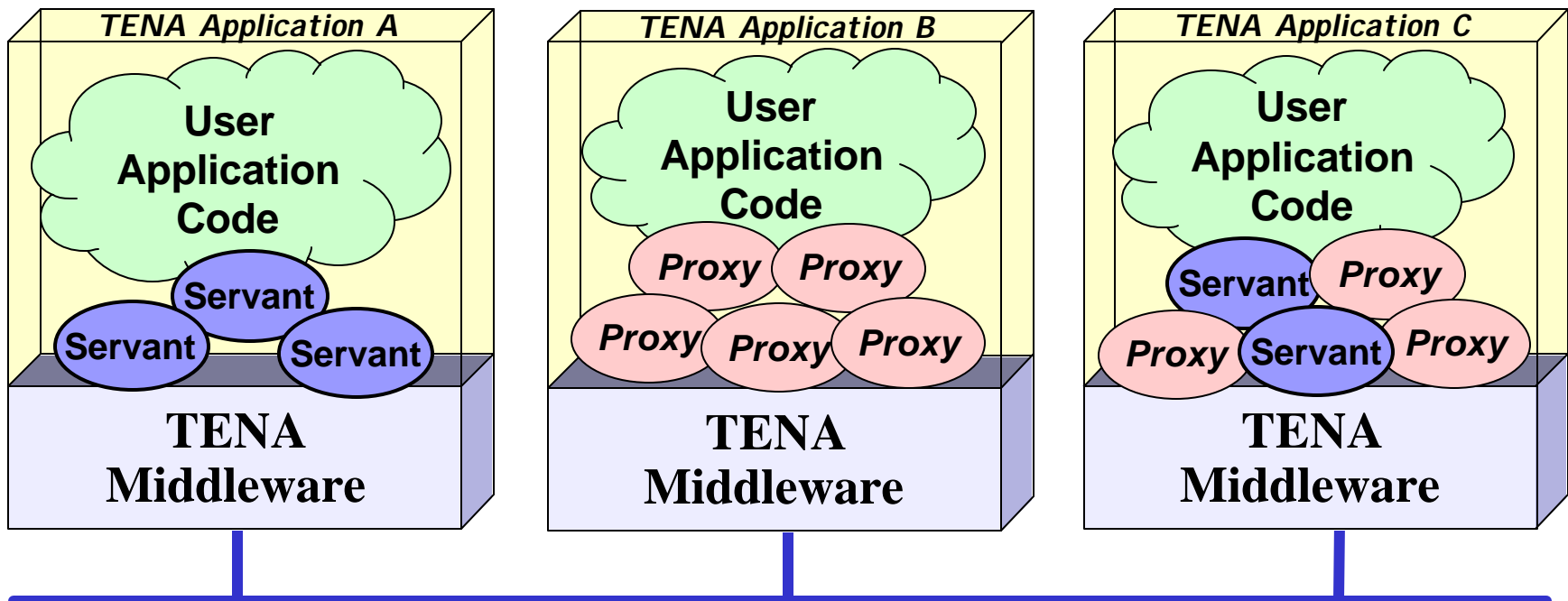
Communication Mechanism (Network, Shared Memory, etc.)



Logical Range Simple Example



- **TENA specifies a peer-to-peer architecture for logical ranges**
 - Applications can be both clients and servers simultaneously
 - In their role as servers, applications serve TENA objects called “servants”
 - In their role as clients, applications obtain “proxies,” representing other applications’ servants. Only servers can write to their servant objects’ publication state
- **The TENA Middleware, the TENA objects, and the user’s application code are compiled and linked together**



Communication Mechanism (Network, Shared Memory, etc.)

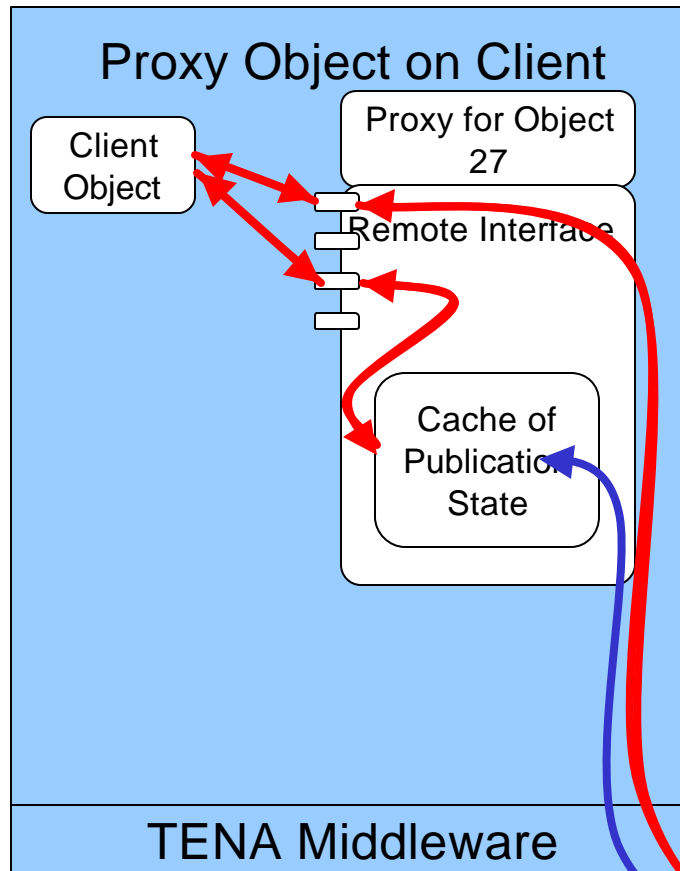


Clients and Proxies; Servers and Servants

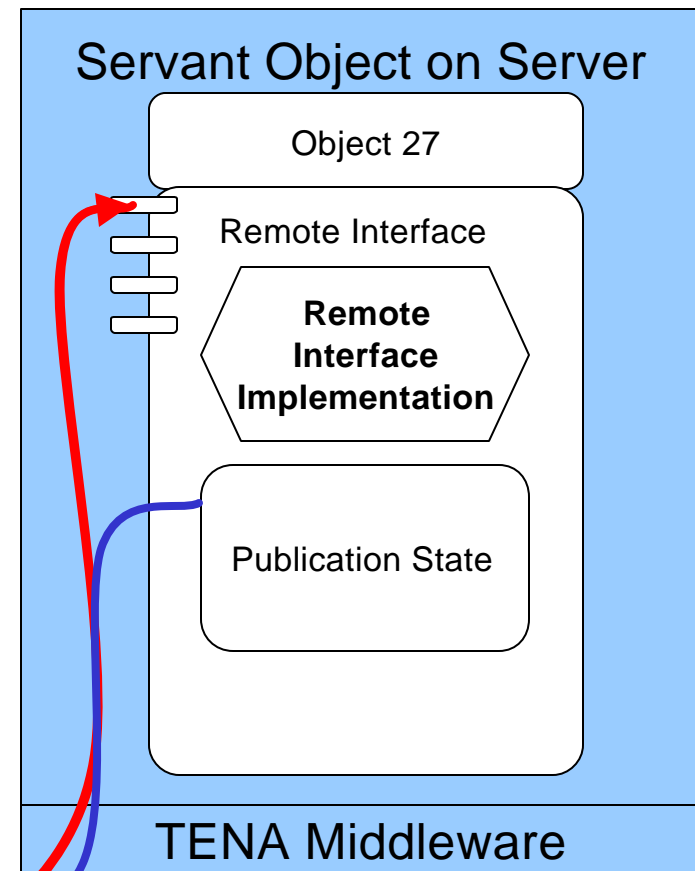


- **When objects are distributed across multiple processes or machines**
 - One object is the “real” object – the one with the implementation
 - All the others are “proxies”

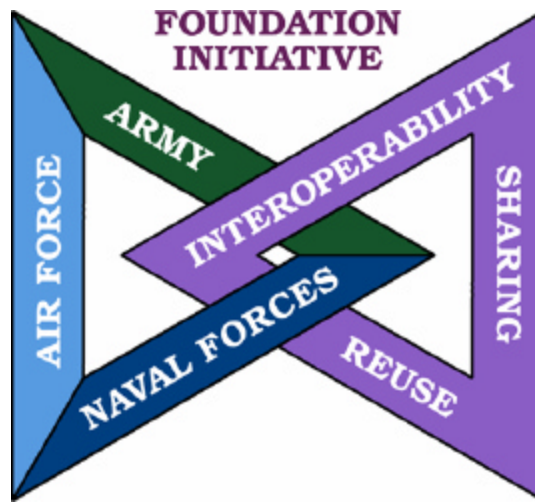
Client Process



Server Process



Network

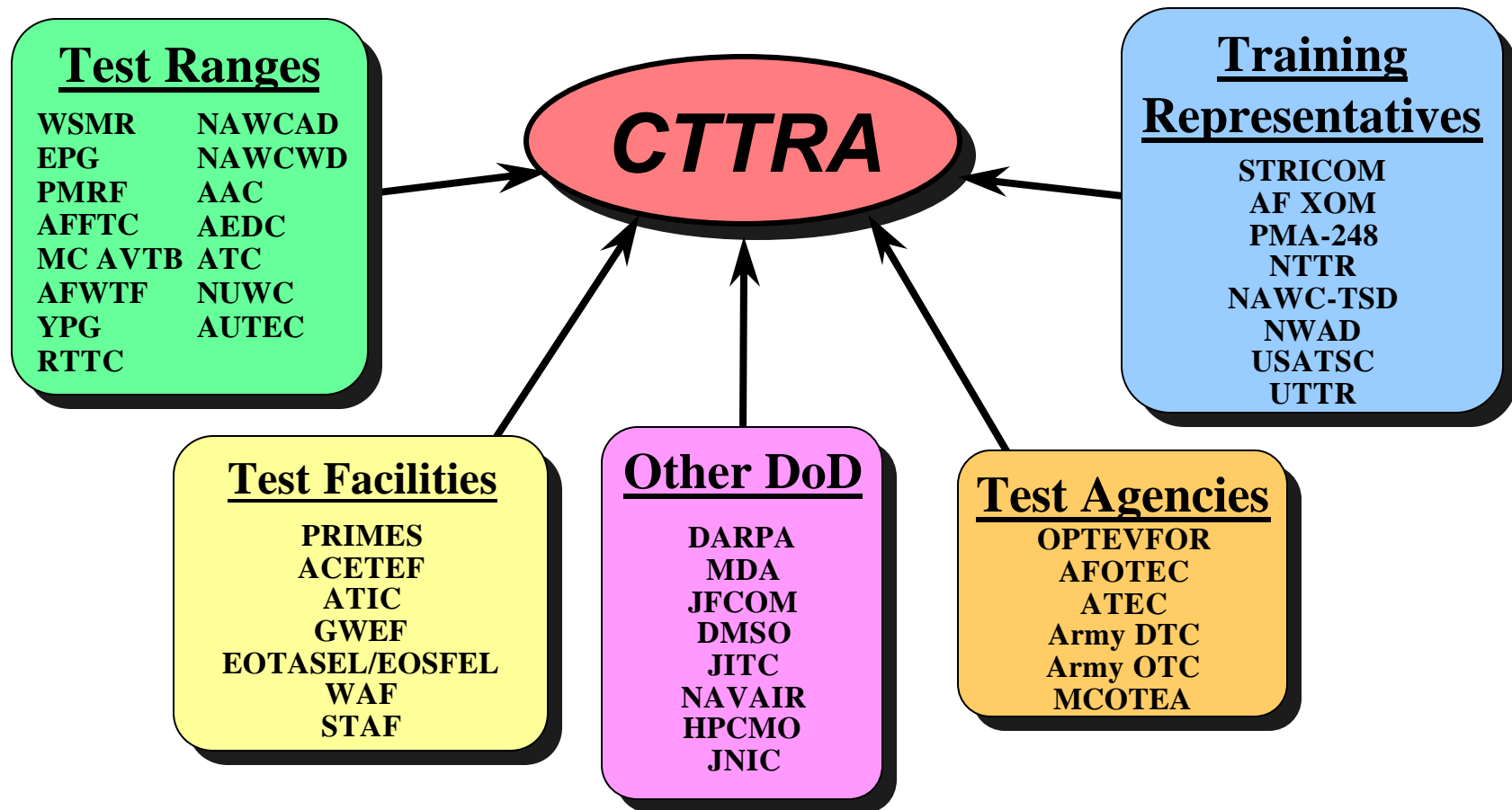


Foundation Initiative 2010 (FI 2010) Update

- FI 2010 Overview
- TENA Architecture
- TENA Implementation Strategy
- Where We Stand



Common Test & Training Range Architecture (CTTRA)



Systems engineers & software developers in the DoD Range and Facility community (both T&E and Training)

13 three-day workshops held (usually every 6-9 months)

CTTRA XIII workshop was held Feb 27-Mar 1



Architecture Management Team (TENA AMT)



- **System Engineers & Technical Leads for the current major stakeholders of TENA**

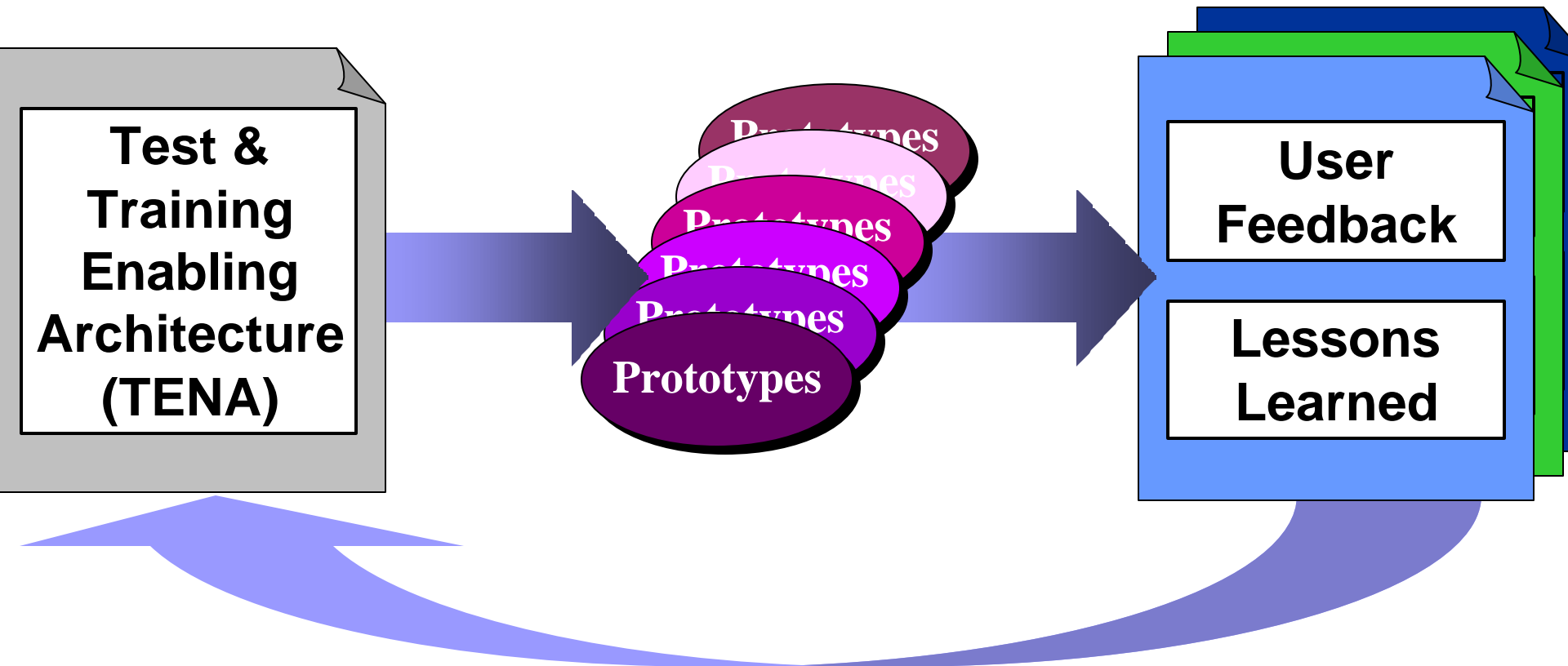
- AAC, Eglin AFB FL
- NUWC, Newport RI
- NAWC-AD, Pax River MD
- WSMR, White Sands NM
- RTTC, Huntsville AL
- EPG, Fort Huachuca AZ
- NAWC-WD, China Lake & Point Mugu CA
- Virtual Proving Ground (VPG)
- Common Training Instrumentation Architecture (CTIA)
- PMRF Synthetic Range
- National Unmanned Underwater Vehicle T&E Center (NUTEC)

***Meetings every
4-6 weeks***

- **Design Decisions / Trade-offs / Status**
- **TENA Use Cases / Prototype Test Strategies**
- **Technical Exchanges of Lessons Learned**
- **Issues & Concerns Identification, Investigation, & Resolution**



Overall Development Strategy



- TENA was revised based on user feedback and lessons learned from working software prototypes
- TENA will be revised in the future based on future prototypes

TENA is based on real-world tests at real ranges



TENA Compliancy Levels



TENA Level 1

- Uses the TENA Middleware
- Defined as TENA Objects

TENA Level 2

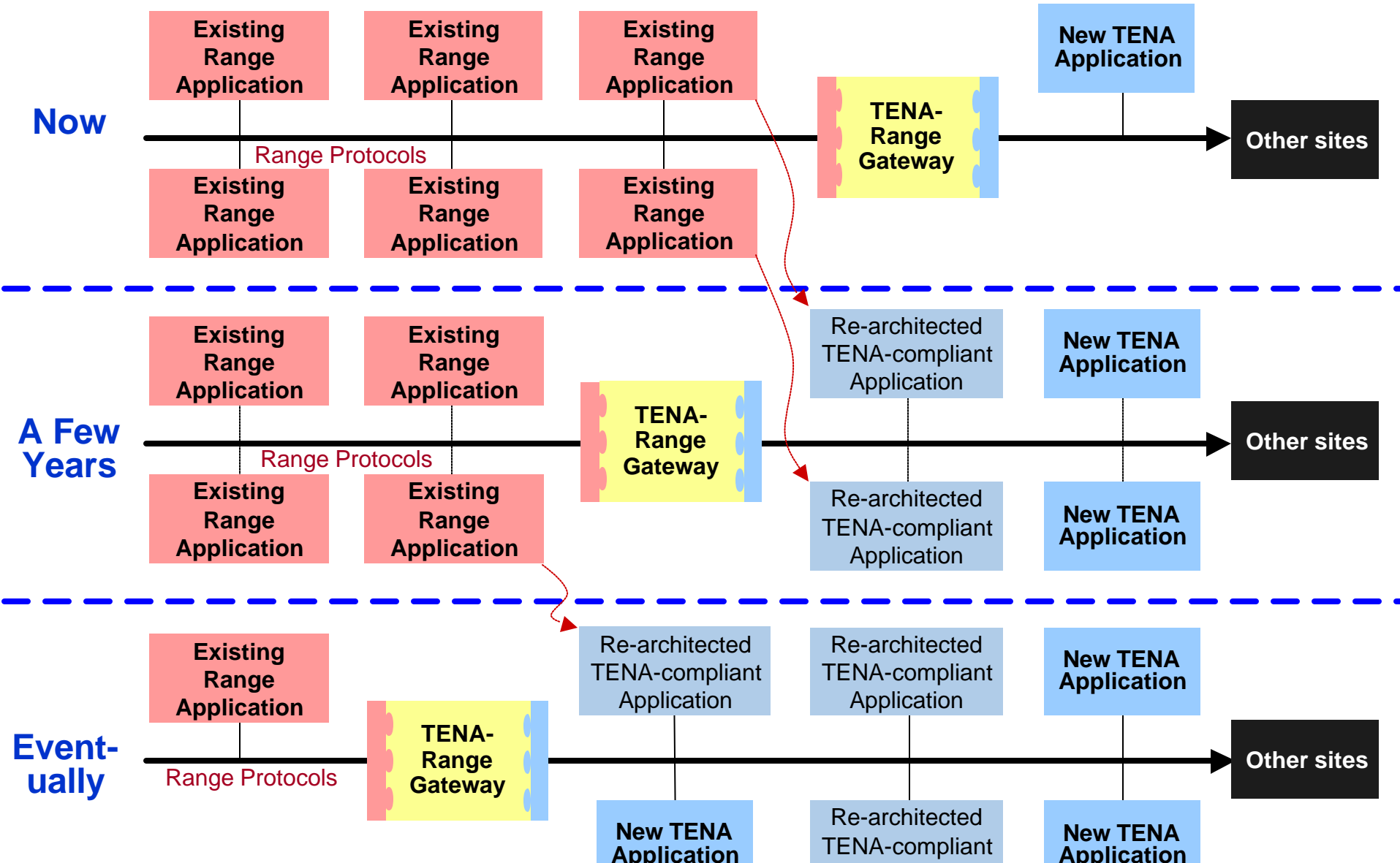
- Standard use and definition of Time
- Only uses the TENA Middleware
- Uses the TENA Middleware
- Defined as TENA Objects

TENA Level 3

- Data Archiving
- Uses RCC Objects (whenever possible)
- Standard Control
- Standard use and definition of Time
- Only uses the TENA Middleware
- Uses the TENA Middleware
- Defined as TENA Objects



Gradual Deployment of TENA





Steps Toward Standardization



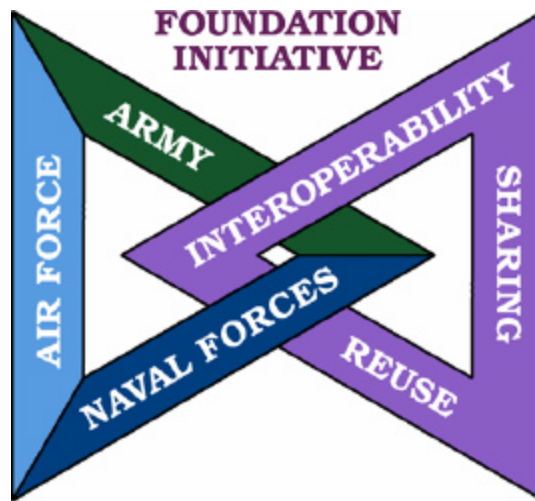
- **TENA Object Model is being developed by the range community as a whole**
- **There are four classifications of object definitions:**
 - **Non-Standard** – these object definitions are not members of any of the other three categories defined below, but are defined solely for the purpose of a given logical range.
 - **Candidate Objects** – those objects, tested in several range events as part of many logical ranges, that have been forwarded to the TENA Architecture Management Team (AMT) as candidates for standardization.
 - **AMT-Approved Objects** – those object definitions, based on the appropriate candidate objects, that have been de-conflicted with other candidate objects by the AMT Object Model Working Group and have been approved for forwarding to the Range Commanders Council (RCC) for standardization.
 - **RCC Standard TENA Objects** – those object definitions that have been approved as a standard by the RCC.



What Still Needs To Be Done



- **Prototyping of other Architecture Features**
 - **Data Streams / Enhanced Security / Data Archiving**
- **Expansion to other Computer Platforms**
 - **SGI / VxWorks / Java**
- **TENA Utilities**
 - **Software to make TENA more user-friendly & efficient**
- **Deployment Roadmaps**
 - **Investment strategies of when to make a system TENA-compliant and to what level**



Foundation Initiative 2010 (FI 2010) Update

- FI 2010 Overview
- TENA Architecture
- TENA Implementation Strategy
- Where We Stand



JFCOM Objectives for MC02



- **“build upon past efforts and advance the concepts that will rapidly co-evolve enhanced joint capabilities for conducting rapid, decisive, joint operations in a 2007 timeframe.”**
- **“emphasize the integration of innovations in doctrine, organization, training, material, leadership, personnel and facilities that enhance the future joint force commander’s operational level command and control”**

Ref: Initial Planning Conference (16-19 jul 01) IPC_msg 131514ZJUN01



JFCOM Objectives for “Range Integration”



- **“Demonstrate potential linkage of Western Ranges to show feasibility for the purposes of joint training and experimentation”**
- **“Demonstrate integration of live and simulated actions in an environment that feeds situational awareness at the operational level.”**

Ref: J7 White Paper of 9 Aug 01, “Range Integration in Support of MC02 Exercise Objectives”



Range Integration in Millennium Challenge 2002 (MC02)



Blue Forces

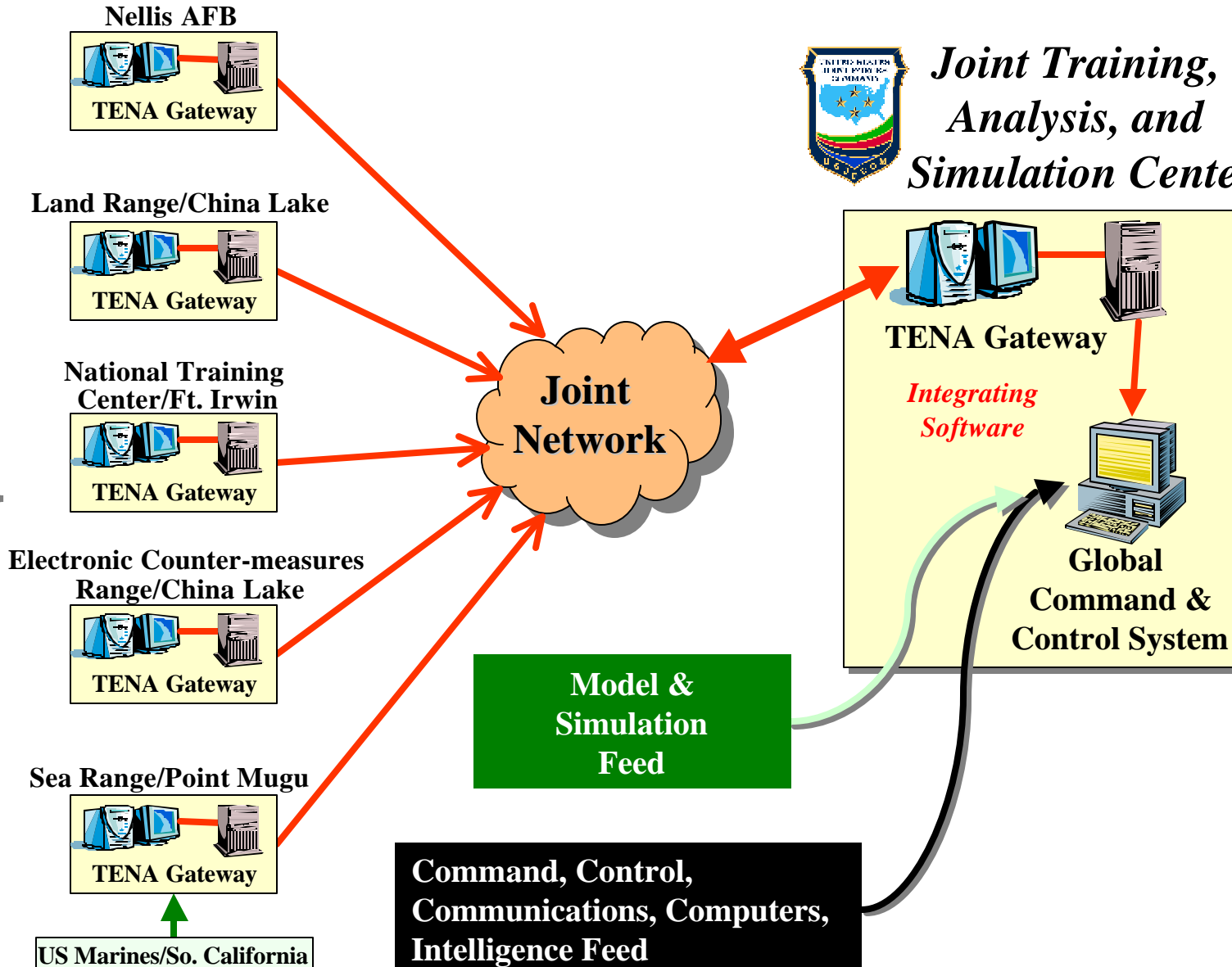


Ships
Ground forces
Aircraft

Opposing Forces



Aircraft & air targets
Ships





FI 2010 Support to MC02



- **Provided TENA Middleware at multiple Ranges and at JFCOM**
 - Software served as the conduit for Ground Truth TSPI data from the Ranges to Command and Control Systems at JFCOM
 - Software worked reliably (operated for days without failure)

- **Provided technical assistance on integrating Range systems**
 - Teamed with JFCOM and Range personnel
 - Supported a gateway approach to interoperability among Ranges to minimize reworking legacy software
 - Helped coordinate requirements definition
 - Researched information on Service experiments
 - Organized technical exchanges
 - Assisted with TENA Middleware installation and testing
 - Facilitated rapid conversion of a legacy Range Display application to TENA compliancy
 - Completed in 2 weeks
 - Distributed to participating Ranges and JFCOM



Summary of What We Have



An **Architecture** for **Ranges, Facilities, and Simulations** to **Interoperate**, to be **Reused**, to be **Composed** into greater capabilities

- **A Working Implementation of the Architecture**
 - TENA Middleware currently works on Windows, Linux, and Sun
- **A Process to Develop and Expand the Architecture**
 - CTTRA Workshops, AMT Meetings, and RCC Coordination
- **A Technical Strategy to Deploy the Architecture**
 - Gateways provide interim solutions as TENA interfaces
- **A Definition of Compliancy**
 - Levels of compliancy to enhance communication among systems engineers and investment decision makers

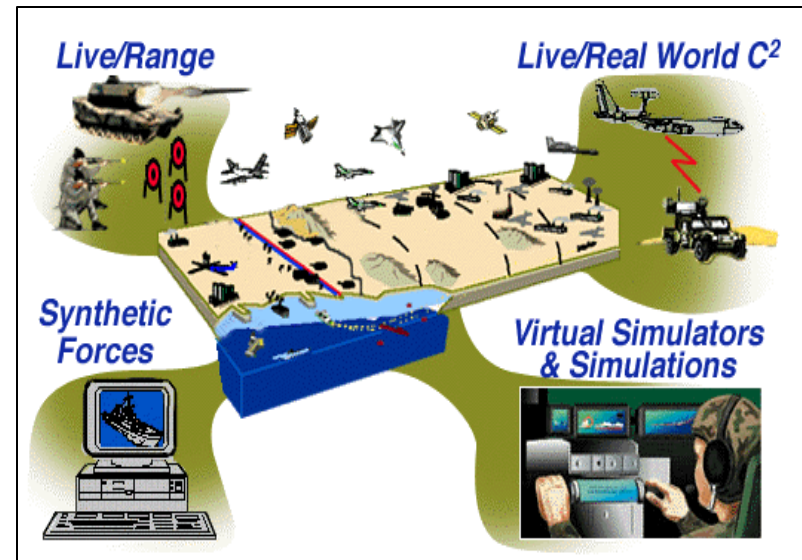
Back-up Slides



The True 'Challenges' in MC02



- Assessment
 - **Data Capture - for both Real Time and Post Event meaningful Analysis**
- Understanding the Joint Battle Space 'Infosphere'
 - **Having the right tools, in the right places, with the right Info Warriors, that could ensure content, reliability, timeliness, accuracy, and relevance of information that was being passed to the key decision makers as - "They don't know - what they don't know..."**
- Mining the Opportunities for Innovation from Observations, Findings, and Analysis:
 - **Sustaining Innovation - simple, easy, leads to incremental improvements**
 - **Disruptive Innovation - difficult, high risk, high payoff, requires strong leadership, and simultaneous co-evolution of multiple moving parts (Doctrine, Organization, Technology, Policy, etc).**





TENA Architecture Overview



TENA Applications

TENA Tools

